

Consumer Acceptance of Nitrite-Free Bacon

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ABSTRACT

Consumer response to bacon cured with and without nitrite was determined. Bacon slices were scored individually on a 7-point hedonic for "like-dislike" responses and consumers indicated preference between the two treatments. Questionnaires from 704 respondents were analyzed for sex, age, and frequency of consumption of bacon. Bacon was "liked moderately" (5.9-6.1 on the hedonic scale) whether cured with or without nitrite. There were no significant differences as a result of sex, age, or frequency of use. Each bacon was preferred by half of the population tested; there was no significant difference between treatments. An acceptable bacon can be prepared by curing without nitrite; the study did not consider shelf stability or the anticlostridial effect of nitrite.

Sodium nitrite added to the cure either deliberately or as the result of bacterial reduction of nitrate has been used in curing meat products from time immemorial. In addition to its anticlostridial activity, nitrite has been used because a desirable characteristic color and flavor were imparted to the meat product. Recently, however, it has been found that nitrite can react with secondary amines to form nitrosamines, a class of compounds found to produce tumors in a number of animal species (6). Nitrosamines, particularly dimethylnitrosamine and nitrosopyrrolidine, have been found consistently in bacon after it has been fried for consumption (2). Reduction, or elimination, of the nitrite used in curing bacon could reduce or prevent formation of nitrosamines. Aside from a consideration of the anticlostridial activity there is a question about producing a conventional product, acceptable to the consumer, with low concentrations of, or no, nitrite.

The role of nitrite in development of characteristic bacon flavor has been investigated infrequently since the report by Brooks et al. (1) that a satisfactory bacon could be made with sodium chloride and sodium nitrite instead of the conventionally used sodium nitrate. These authors did not present satisfactory sensory evaluation of their samples. Mottram and Rhodes (7) investigated the flavor of Wiltshire bacon, demonstrating that salt pork flavor decreased and cured flavor increased as sodium nitrite

concentration increased in the cure. However, the product prepared without nitrite was rated as containing identifiable bacon flavor. There are differences between British and American procedures in preparing bacon, as well as in flavor preferences. British pork is, for the most part, leaner than the American, and the Wiltshire cure did not include smoke. The bacon was prepared essentially by cooking in steam. The British perception of bacon flavor, therefore, varies considerably from the American, and results of Mottram and Rhodes may not be directly applicable to studies in the United States. Herring (4) also demonstrated that addition of nitrite to the cure resulted in greater acceptance of bacon. In his study, too, there was acceptance of the bacon processed without nitrite, although at a lower level, particularly in the initial stages of storage. Green and Price (3), studied the effects of sodium chloride and sodium nitrite in developing cured flavor in ground fresh pork. They obtained low cured flavor scores in the absence of NaCl. Cured flavor was developed in the presence of NaCl, with only slightly higher panel scores when nitrite was used in addition to the NaCl. Kimoto et al. (5) observed a similar effect. On curing the bellies with NaCl alone, they obtained characteristic bacon flavor, which was only slightly improved by addition of nitrite to the cure.

An opportunity to obtain large-scale consumer reaction to bacon prepared with and without nitrite became available recently at an Open House demonstration at Eastern Regional Research Center. The information presented herein is the result of the data obtained in this study.

EXPERIMENTAL

Bacon

The bacon for this study was prepared by the processor of a national brand of bacon. Sixteen randomly selected pork bellies in two groups of eight bellies each were pumped to contain either 0 ppm sodium nitrite or 120 ppm sodium nitrite. The basic cure pickle for both groups contained salt, sugar, sodium tripolyphosphate, and ascorbate. The bellies were pumped to 113% of green weight, and smoked and cooked to an internal temperature of 55 C, using a commercial program. Chilled and formed slabs were sliced to 10-11 slices per inch, vacuum packaged in 1-lb. units, and refrigerated until used in the test.

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Sample preparation

The test was conducted 15 days after the bacon was pumped. Packages were removed from the refrigerator 15-20 min before frying to facilitate separation of strips. The bacon was fried in electric fry pans calibrated at 165 C and turned frequently until the adipose tissue of both treatments was golden-brown in color and the lean of the bacon cured with nitrite was dark red, while the lean of the bacon cured without nitrite was reddish-brown. Fried bacon was kept warm under infrared lamps although for the most part the flow of visitors was so great bacon was not held in the warming pan for more than 5 min.

Test procedure

Plywood partitions on the laboratory benches made temporary booths for the panelists. Regular fluorescent lighting was used and no attempt was made to equalize color differences in the bacon samples. Visitors to the laboratory were given the form shown in Fig. 1 with brief instructions on the procedure. In the booths, they were supplied with a plate containing the two strips of bacon and a cup of water. The panelists were asked to sample each strip one at a time, indicating their reaction to the first strip on a 7-point hedonic scale before going on the second strip. They were then requested to indicate their preference between the two samples.

To reduce the possibility of positional effects of the samples on the responses of the consumer panelists, the position of the two bacon treatments on the plate was continuously alternated.

Statistical analysis

The responses for the two bacon samples were analyzed by an analysis of variance with bacon sample, sex, age, and frequency of eating bacon as factors. All 3- and 4-way interaction terms were considered negligible and were combined with the error sum of squares (9). The preference responses were analyzed by the method of Roessler et al. (8) to determine whether there was a significant difference between the number of consumers preferring the nitrate cured sample and the number preferring the sample cured without nitrite.

RESULTS AND DISCUSSION

Approximately 3,000 people visited the Center during the 8-h Open House demonstration. Of these, 704 participated in the test to evaluate consumer reaction to bacon prepared with and without sodium nitrite in the cure. The 704 responses were from 354 female and 350 male participants. The distribution of the consumer respondents according to age and frequency of eating bacon is shown in Table 1. There were 215 participants under 21 years of age, 121 between 21 and 30, 108 between 31 and 40 and 260 over 41. Frequency of eating

TABLE 1. Distribution of panelists by sex, age, and frequency of eating bacon

Sex	Age, years				Total
	< 21	< 30	< 40	> 41	
Female	82	70	62	140	354
Male	133	51	46	120	350

Frequency of consumption by sex				
Sex	Once a week	Once a month	Less frequently	Total
Female	116	129	109	354
Male	161	114	75	350

Frequency of consumption by age				
Age	Once a week	Once a month	Less frequently	Total
<21	84	80	51	215
<30	43	49	29	121
<40	42	38	28	108
>41	108	76	76	260

bacon was divided into: at least once a week — 277 respondents, at least once a month — 243, and less frequently than once a month — 184. Further distribution of these groups by sex and by age is shown in the table.

The evaluation of the consumers' responses with respect to their like or dislike of the bacons prepared with and without nitrite are given in Table 2. There was

TABLE 2. Hedonic evaluation and preference selection of bacon cured with and without nitrite

Category	Average rating ^a		Preference ^b	
	Nitrite cure (1)	No nitrite cure (2)	(1)	(2)
Female	6.2	6.1	176	178
Male	6.1	6.0	176	174
<21	6.1	5.9	115	100
<21-30	5.9	5.9	60	61
<31-40	6.2	6.1	54	54
>41	6.2	6.1	123	137
Eat once a week	6.2	6.1	132	145
Eat once a month	6.1	6.1	122	121
Eat less frequently	6.0	5.8	98	86

^aBased on 7-point scale: 1 = dislike very much; 7 = like very much.

^bNumber of consumers preferring the particular sample of bacon.

Sex _____		Age: Under 20 _____;		21 to 30 _____;		31 to 40 _____;		Over 40 _____.	
DO YOU EAT BACON:		At Least Once a Week _____;		Once a Month _____;		Less than Once a Month _____.			
Sample No.	Like Very Much	Like Moderately	Like Slightly	Neither Like Nor Dislike	Dislike Slightly	Dislike Moderately	Dislike Very Much		
WHICH SAMPLE DO YOU PREFER? _____									

Figure 1. Questionnaire used for consumer panel.

no statistically significant difference ($p = .05$) between the consumers' responses to the two bacon preparations due to sex, age, frequency of use, or any of the interaction terms. Both bacons were liked moderately, receiving, on a 7-point hedonic scale, an average rating of 6.1 for the conventionally cured bacon and 6.0 for the bacon cured without nitrite.

The panelists were requested to indicate their preference between the two bacons, although this information could have been obtained from the hedonic ratings assuming the higher rating indicated the preferred sample. The preference information is summarized in Table 3 where the number of consumers in every combination of sex, age, and frequency of consumption is divided into those preferring one sample or the other. The statistical analysis showed a significant difference ($p = .05$) only in the case of 21-30 year old men who

TABLE 3. Consumer preference for bacon cured with or without sodium nitrite

Frequency of eating bacon	Age			
	< 21	21-30	31-40	> 41
<i>Females</i>				
Eat once a week	14/9 ^a	8/11	12/12	20/30
Eat once a month	22/13	12/21	12/10	17/22
Eat less frequently	14/10	10/8	8/8	27/24
<i>Males</i>				
Eat once a week	30/31	9/15	9/9	30/28
Eat once a month	22/23	11/5	8/8	18/19
Eat less frequently	13/14	10/1	5/7	11/14

^aUpper figure is the number of consumers who prefer bacon cured with nitrite; lower figure represents number of consumers preferring bacon cured without nitrite.

consume bacon less than once a month. There was no significant difference in any other category of panelists.

Thus, bacon, 15 days after processing without nitrite in the cure, was as acceptable to a large group of consumers as was bacon cured with nitrite in the same manner. This study was not designed to consider the potential risk of the growth of *Clostridium botulinum* or the possible effect on oxidative stability in the elimination of nitrite from the cure.

REFERENCES

1. Brooks, J., R. B. Haines, T. Moran, and J. Pace. 1940. The function of nitrate, nitrite, and bacteria in the curing of bacon and hams. Dept. Sci. and Indust. Res. Food Invest. Spec. Report No. 49 (Great Britain).
2. Fazio, T., R. H. White, L. R. Drisold, and J. W. Howard. 1973. Nitrosopyrrolidine in cooked bacon. J. Assoc. Off. Anal. Chem. 56:919-921.
3. Greene, B. E., and L. G. Price. 1975. Oxidation-induced color and flavor changes in meat. J. Agric. Food Chem. 23:164-167.
4. Herring, H. K. 1973. Effect of nitrite and other factors on the physico-chemical characteristics and nitrosamine formation in bacon. Proc. of the Meat Industry Research Conf., March 22-23, 1973, Chicago, Illinois. p. 47-60.
5. Kimoto, W. I., A. E. Wasserman, and F. B. Talley. 1976. Effect of sodium nitrite and sodium chloride on the flavor of processed pork bellies. Lebensmitt.-Wiss. u. Technol. 9:99-101.
6. Magee, P. N., and J. M. Barnes. 1967. Carcinogenic nitroso compounds. Adv. Cancer Res. 10:163-246.
7. Mottram, D. S., and D. N. Rhodes. 1973. Nitrite and the flavor of cured meat. Interantional Symposium of Nitrite in Meat Products, Zeist, The Netherlands.
8. Roessler, E. B., G. A. Baker, and M. A. Amerine. 1956. One tailed and two tailed tests in organoleptic comparisons. Food Res. 21:117-121.
9. Snedecor, G. W., and W. G. Cochran. 1967. Statistical methods, 6th ed. Iowa State University Press, Ames, Iowa.